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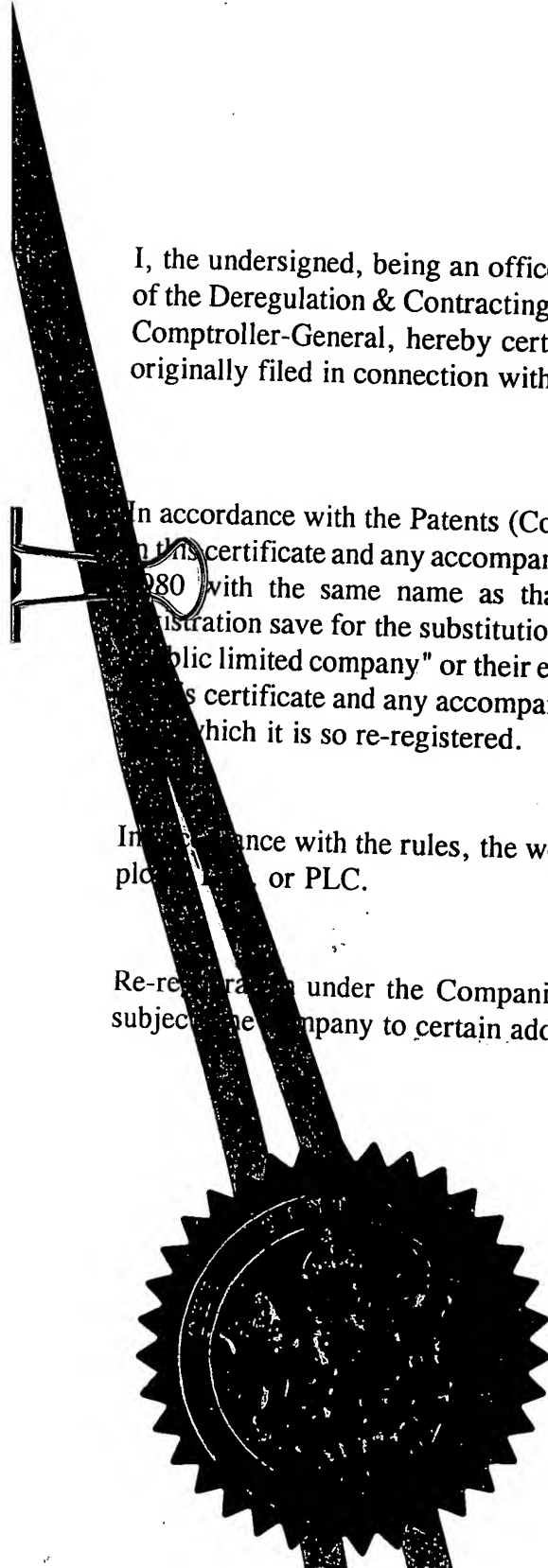
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P016340GB AP FAG

13 MAR 2003

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GENTECH INTERNATIONAL LIMITED
Grangestone Industrial Estate
Girvan
Ayrshire
KA26 9PS

Patents ADP number (*if you know it*)

If the applicant is a corporate body, give the country/state of its incorporation

England & Wales

4453403001

4. Title of the invention

"Improvements in and Relating to Liquid Level Indicators"

5. Name of your agent (*if you have one*)

D Young & Co

"Address for service" in the United Kingdom to which all correspondence should be sent (*including the postcode*)

21 New Fetter Lane
London
EC4A 1DA

Patents ADP number (*if you know it*)

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Date 13 March 2003

D Young & Co (Agents for the Applicants)

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Improvements in and Relating to Liquid Level Indicators

The present invention relates to a device for and method of indicating a liquid level in a container, in particular, although not exclusively, for volatile liquids.

5 Most gases will condense into a liquid form if the temperature of the gas is reduced sufficiently. However, the temperature at which gas to liquid condensation takes place at atmospheric pressure is often very low, for example, at atmospheric pressure propane gas condenses to a liquid at -43°C .

10 The temperature at which condensation occurs can be increased by increasing the pressure of the gas. Some gases, such as propane and butane, for example, can be easily condensed into a liquid form by compressing the gas. Such compressed gases are often known as volatile liquids, because they will vaporise to form a gaseous state as soon as the pressure is reduced. Therefore, in order to maintain the compressed gas in the liquid form the pressure must be maintained. This is usually achieved by storing
15 the volatile liquid in pressurised containers.

To allow for removal of the gas from the pressurised container the container is usually fitted with a tap arrangement. When the tap is opened, the pressure in the container is reduced and the volatile liquid begins to vaporise. The vapour exits the container via the tap and will continue to do so until the tap is closed. After the tap is
20 closed, the volatile liquid will continue to vaporise until the pressure inside the container becomes sufficient to maintain the gas in the liquid state.

As the volatile liquid vaporises energy is drawn from the body of the liquid to fuel the vaporisation process. Therefore, the temperature of the body of liquid will fall as the liquid vaporises.

25 A problem associated with pressurised containers of volatile liquids is that it is generally difficult to detect the level of liquid left in the container. Therefore, it is difficult to ascertain when the container will become emptied. This is a particular problem in use of liquid propane and butane cylinders with, for example, gas powered grills, patio heaters, room heaters, refrigerators, cookers and the like. In such instances
30 it is unusual for a consumer to have a spare fuel cylinder available, and it can be very inconvenient if the gas bottle becomes empty part way through cooking a meal or such

like. A device is available for indicating the liquid level remaining in a propane gas bottle. The device comprises a flexible sheet in which a plurality of rows of LCD temperature sensors are embedded. The device contains a magnetic material so that it can be attached to the exterior sidewall of a gas bottle just above the base. In use, each
5 sensor of the device senses the temperature of the bottle and the sheet changes colour at the points where a temperature at or below a set temperature is detected. Thus the device is arranged to change colour below the liquid level.

Whilst such a device is cheap to manufacture and easy to use, it can be adversely affected by external temperature changes, such as sunlight and/or wind or
10 rain incident on the device. Furthermore, the device needs to be regularly observed.

It is an object of preferred embodiments of the present invention to provide an alternative liquid level indicator.

The present invention provides a liquid level indicator comprising a plurality of temperature sensors spaced apart from one another, a processor designed to process the
15 output of two at least of the plurality of temperature sensors, and an indicator means, designed to provide an indication of the liquid level in response to the output of the processor.

Suitably, the liquid level indicator indicates the level of a volatile liquid in a pressurised container.

20 Suitably, the liquid level indicator comprises two temperature sensors spaced one above the other when the indicator device is arranged for use. However, the liquid level indicator may comprise more than two temperature sensors. In the latter case, at least one of the temperature sensors should be arranged to be above the other sensors when the indicator device is arranged for use. Preferably, all of the temperature
25 sensors are arranged one above another when the indicator device is arranged for use. In addition, the processor should process the output of two temperature sensors that are arranged to be one above another sensor when the indicator device is arranged for use.

Any suitable temperature sensor may be used. One or more of the temperature sensors suitably comprises a thermistor.

30 The liquid level sensor is preferably designed to take the output of the at least two temperature sensors of the plurality of temperature sensors at pre-set time intervals. The output of the at least two temperature sensors of the plurality of

temperature sensors taken at each pre-set time interval is preferably taken at substantially the same time. The liquid level indicator may be designed to take intermittent readings from the temperature sensors at any suitably time interval. For example, the liquid level indicator may be designed to take a reading from the temperature sensors once every 30 seconds, once every minute, once every 5 minutes or once every 10 minutes.

The processor may comprise any suitable device or arrangement. Preferably, the processor includes a microchip. The processor is suitably designed to process the output signals from the two at least temperature sensors in a pre-set manner against one or more pre-set conditions, and produce an actuation signal to the indicator means dependent upon the results of the comparison.

The processor may be programmed to process the output signals from the temperature sensors in various ways. For example, the processor may simply compare the output signal, for example the output voltage, of one or more pairs of the temperature sensors to determine the difference between the outputs. This difference may then be compared to one or more pre-set conditions to determine what signal to output to the indicator means.

Alternatively, or in addition, the microchip may convert the output from one or more of the temperature sensors into a calculated temperature value using a look-up table, or the like. The processor may then be used to determine the temperature difference between two calculated temperature values, which temperature difference may then be compared to one or more pre-set conditions to determine what signal to output to the indicator means.

The processor may store measurements taken from the temperature sensors at some or all of the time intervals. The processor may store the measurements taken from one or more sensor. The processor may store the measurements as either a voltage measurement or as a calculated temperature value. Alternatively, or in addition, the processor may store the differences between the measurements, either as a difference in the voltage measurements or as a temperature difference.

The actuation signal generated by the processor to activate the indication means may be a continuous signal, an intermittent signal or no signal.

For example, the processor may produce a continuous actuation signal that varies, for example in frequency, depending upon the particular state the indicator is required to indicate.

Alternatively, the processor may be programmed to produce an actuation signal
 5 only if the liquid level is detected as being at or below the level of the liquid level indicator device. In this case, the indicator means may only be activated when the liquid level is detected as being at or below the level of the liquid level indicator device and a signal is emitted by the processor, and otherwise the indicator means will remain inactive. Alternatively, the indicator means may provide an indication that the
 10 liquid level is above the liquid level indicator when no signal is received from the processor, and change the indication when a signal is received from the indicator. The indication of low liquid level may also be different when the liquid level is in the region of the liquid level indicator device from when the liquid level is below the liquid level indicator device.

15 As a further alternative, the processor may be programmed to issue an intermittent signal or a signal of differing frequency dependant upon the liquid level detected by the indicator device. In this case, the indicator means could use the actuation signal to provide a continuous indication of the liquid level, which changes as the liquid level falls below the level of the indicator.

20 The indicator means may comprise an audible alarm, for example a piezo-electric sound generator. The audible alarm may comprise a distinctive tune, in order to make the alarm more easily distinguished over other electronic sounds that may be emitted in the surrounding area. Alternatively, or in addition, the indicator may comprise a visual display such as an LED or a liquid crystal display (LCD).

25 Suitably, the processor is also designed to detect when the container to which it is attached is in use. This may be achieved by programming the processor to compare the measurements of one or more of the plurality of temperature sensors at one point in time with the measurements of the same sensor at a later point in time against one or more pre-set conditions. Alternatively, or in addition, the processor may be
 30 programmed to compare the difference in voltage measurements or the temperature difference, both referred to above, at one point in time with the difference in voltage measurement or temperature difference at a later point in time, against one ore more

pre-set conditions. The processor may look for a difference in the readings in either direction, i.e. either positive or negative.

In this case, the processor may be programmed to send out an actuation signal to the indicator means only when the processor detects that the container is in use.

5 Suitably, the processor, the plurality of temperature sensors and the indicator means are mounted onto a printed circuit board.

The liquid level indicator is suitably powered by one or more batteries, preferably by two AA batteries.

10 The level indicator may comprise operation indicative means to indicate that the liquid level indicator is operational. The operation indicative means may comprise one or more LED's, which may be arranged to provide either an intermittent or a continuous display when there is sufficient power in the batteries to operate the liquid level indicator. The one or more LED's of the operation indicative means may be provided by any LED of the indicator means. Alternatively, the LED's of the
15 operation indicative means may be separate from any LED of the indicator means.

Suitably, the liquid level indicator further comprises a housing. The housing may comprise a main body and a cover. The cover may be attached to the main body, but is suitably separable from the main body of the housing.

20 Suitably, the main body contains, part at least of each of the plurality of temperature sensors, the processor, part at least of the indicator means and the one or more battery. Suitably, part at least of each of the plurality of temperature sensors extends from an exterior surface of the housing. The housing may further comprise a divider to separate the electronic components from the one or more battery, so that the battery can be changed without exposing the electronic components.

25 Suitably, the housing has a generally rectangular conformation having a front wall, a back wall, a top wall, a bottom wall and two opposing sidewalls. One or more of the walls of the housing may be moulded to have a non-planar conformation.

30 The front wall of the main body may be moulded to have a box of generally rectangular conformation extending therefrom. Suitably, the processor, the plurality of temperature sensors, and the indicator means are located within the box extending from the front wall. Suitably, the one or more battery is located in the main compartment of the main body. Preferably, a dividing plate is located inside the main

body of the housing to separate the interior of the rectangular box extension of the front wall from the main compartment of the main body.

The main body of the housing suitably provides the front wall, the box extension from the front wall, the bottom wall, an interior surface of a top wall and
 5 part at least of each sidewall of the housing. The cover of the housing suitably provides the back wall, part at least of each side wall, and an exterior surface of the top wall.

Suitably, in use, the housing is arranged with the front wall facing a container to which the liquid level sensor is to be attached. Part at least of each of the plurality
 10 of temperature sensors extends from the surface of the front wall, such that when the device is attached to a container in use, each temperature sensor contacts the surface of the container to which the device is attached. One at least of the plurality of temperature sensors should be above others of the plurality of temperature sensors when the liquid level indicator is arranged for use.

15 Preferably, the housing is designed to provide the temperature sensors with a degree of protection from the external environment, including heat and/or moisture. Suitably, each of the plurality of temperature sensors is spaced below the top wall of the housing, such that the upper part of the housing will provide some protection for the uppermost temperature sensor from the external environment. Suitably, each of
 20 the temperature sensors is located towards the central meridian of the front wall of the housing, such that the sides of the housing will provide a degree of protection for the temperature sensors from the external environment.

Protection of the sensors may be effected by shaping the housing such that parts of the housing provide a shield against the external environment. For example,
 25 the upper end, when arranged for use, may comprise by a lip extending from an edge of the cover. Preferably, the lip extends from the top wall of the cover. The housing may further comprise a skirt around the region in which the temperature sensors are located extending from the surface of the housing, to provide a further shield from the external environment.

30 The lip and skirt portions may be provided by moulded section of the housing, which extend from a surface of the housing. Alternatively, a separate element may be attached to the surface of the housing to provide the lip and skirt portions. Any

suitable material may be used to provide the shielding portions. For example, a foam strip may be attached to the exterior of the housing in appropriate locations to shield the temperature sensors from the external environment.

5 The shielding portions may be arranged such that a sealed space around the temperature sensors is effectively formed when the liquid level indicator is arranged against a surface for use.

The liquid level sensor may further comprise attachment means for attaching the device to a container of liquid to be monitored. The attachment means may be any suitable means, for example, handles and a strap, but is preferably provided by one or
10 more magnet. Suitably, the one or more magnet is contained in the housing in the region of the front wall. Preferably, the one or more magnet is located in the box extending from the front wall.

The housing may include a hole in a wall thereof to allow sound emitted from any audio alarm to be transmitted more effectively from the device. The hole is
15 suitably located in the region of the sound generator. The hole is suitably filled by the sound generator, such that substantially no opening between the exterior environment and the interior of the housing exists at that location. The housing may be shaped to more effectively allow for transmission of the sound from the level indicator.

The housing may comprise a drainage hole to allow liquid entering the housing
20 to drain therefrom.

Suitably, the section of the housing containing the one or more battery is substantially splashproof.

In use, the liquid level indicator is suitably attached to the lower part of a pressurised container holding a volatile liquid. The liquid level indicator is arranged
25 on the container such that two at least of the plurality of temperature sensors are arranged spaced one above another.

The processor periodically takes a measurement indicative of the temperature of the surface of the container at that the location of each sensor. The output from each temperature sensor is transmitted to the processor. The processor may then
30 convert the measurement of the temperature sensors into an calculated temperature value. The processor then compares the measurement of at least two temperature sensors to determine the difference between the pair of sensors. If a difference is

greater than a pre-set amount, a signal will be transmitted by the processor to activate the indicator means.

5 If the level indicator is also programmed to compare different readings from the same temperature sensor at different times, an additional step will be carried out by the processor. In this case, the processor will receive, and preferably store, a set of temperature measurements at one point in time and then will receive, and preferably store, another set of temperature measurements at a later point in time. The processor will then compare the measurement of each sensor taken at the later time with the measurement of the same sensor taken at the earlier time, to determine whether or not
10 the overall temperature of the container is falling with time. If the processor assesses that the overall temperature of the bottle is falling, or at least not rising, with time, the processor will then proceed to compare the temperature readings of the temperature sensors at one of the points in time, as described above, to determine whether or not a signal should be sent to activate the indicator.

15 As the compressed liquid is being used, the liquid will be vaporising and latent heat of vaporisation will be removed from the body of the liquid remaining in the container. Hence, the temperature of the body of liquid in the container will gradually decrease with time.

20 In addition, although the temperature of the body of liquid will generally decrease whilst the liquid is being used, at any point in time, the temperature of the body of liquid will be substantially uniform throughout. However, the gaseous vapour above the liquid in the container will exhibit an increasing temperature profile from the liquid surface up towards the top of the container as a result of external environmental heating.

25 Therefore, if a comparison of the temperature measurement of two or more temperature sensors at one point in time shows substantially no temperature difference, then either both of the sensors are located below the liquid surface, or the container is not in use. If a comparison of the temperature measurements of two or more sensors at one point in time shows a difference, the surface of the liquid is probably at or below
30 the level of the sensors. The processor may be programmed to monitor the variation of measurements taken by each sensor as the container is in use, in order to determine

between when the liquid level is at the position of the indicator device and when the liquid level is below the position of the liquid level indicator.

The processor may send a different signal to the indicator means dependent upon which of the above-mentioned conditions applies. The indicator means may provide a continuous signal that changes to correspond to the condition detected, or the indicator means may provide an alarm signal only if the liquid level is detected as being in the region of the temperature sensors, or below the level indicator. In each case, the indicator means may issue a different type of indication to signal when the liquid level is between the sensors or when the liquid level is below the level indicator device.

The present invention further provides a method of indicating a liquid level for a volatile liquid in a pressurised container comprising, taking a first measurement indicative of temperature at a first point on the pressurised container, taking a second measurement indicative of temperature at a second point on the pressurised container, the second point being below the first point, processing the first and second measurements to determine the difference between the two measurements and then comparing the difference against a pre-set condition, sending a signal to an indicator means dependent upon the result of the comparison step, and indicating the liquid level in accordance with the indicator signal.

The method may further include, taking a second set of temperature measurements at the first and second points at a later time. In this case, the processing step suitably further comprises, comparing the measurement from a temperature sensor at the later time to the measurement from the same temperature sensor at the earlier time to determine whether or not the overall temperature of the container is falling or at least not rising with time. This processing step is suitably carried out before the processor compares the measurements taken from different temperature sensors at the same, as set out above. If the temperature of the container is falling with time, then the method may continue with the processing step set out above. If the temperature of the container is not falling with time, then the method may return to the preceding measuring step. In this case, the method may not involve sending a signal to the indicator means until a fall of temperature of the container with time is detected.

The measurement indicative of temperature taken from the temperature sensors may be processed as a voltage output from the sensors. Alternatively, the output of the temperature sensors may be converted to a calculated temperature value before processing commences.

5 If a comparison of the temperature measurements at one point in time shows substantially no temperature difference, then the sensors are more than likely located below the liquid surface or the container is not in use. In this case, the method may involve sending no signal to the indicator means and the indicator means may provide no indication of the liquid level. Alternatively, if the indicator means receives no
10 signal, the indicator means may produce an indication that the liquid level is above the location of the liquid level indicator.

 If a comparison of the temperature measurements at one point in time shows a significant difference, the surface of the liquid is probably at or below the first and/or second points on the container. In this case, a signal is sent to the indicator means, and the
15 indicator means provides an indication that the liquid level is at or below the first point and the second point on the container.

 A different signal may be sent to the indicator means dependent upon which of the above-mentioned conditions applies. The indicator means may provide a continuous indication that changes to correspond to the condition detected, or the
20 indicator means may provide an indication of the liquid level only if the liquid level is detected at being between the first and second points on the container, or below the level indicator. In each case, the indicator means may issue a different type of indication to signal when the liquid level is between the sensors or when the liquid level is below the level indicator device.

25 The present invention advantageously provides a liquid level indicator and method of indicating a liquid level that is less susceptible to interference from external environmental effects than the prior art device. In addition, a preferred embodiment of the present invention provides for indicating the liquid level only when the container to which the liquid level indicator is attached is in use. Furthermore, if the
30 liquid level indicator comprises an audible alarm, it doesn't have to be regularly visually checked to determine the liquid level. In this case, a user will be alerted to the low liquid level.

The intermittent taking of readings from the temperature sensors prolongs the useful life of the batteries.

All features of any embodiment of the present invention may be used with any other embodiment of the present invention.

5 The present invention will now be described, by way of example only, with reference to the following schematic drawings, in which:-

Figure 1 is a front view of a liquid level indicator;

Figure 2 is a cross-sectional side view of the device of figure 1;

Figure 3 is a side view of the device of figure 1;

10 Figure 4 is a perspective view from the top end and the rear of the device of figure 1;

Figure 5 is a perspective view from the front of the device of figure 1;

Figure 6 is a plan view from the top of the device of figure 1;

Figure 7 is plan view from underneath the device of figure 1;

15 Figure 8 is a side view of the main body of figure 1;

Figure 9 is a perspective view from one side and the front of the cover of the housing of the device of figure 1;

Figure 10 is a side view of the cover of figure 9;

20 Figure 11 is a flow diagram of a first embodiment of a method of indicating a liquid level of a volatile liquid in a pressurised container, and

Figure 12 is a flow diagram of a second embodiment of the method of a method of indicating a liquid level of a volatile liquid in a pressurised container.

The device of figures 1 to 10 comprises a housing 2 having a main body 4 (fig 8) and a cover 6 (figs 9 and 10).

25 The main body 4 comprises a generally rectangular main portion 8 and a box-like, generally rectangular portion 10 extending therefrom. The main portion 8 and the box-like portion 10 are separated by means of a dividing plate 12 (fig 2). The box-like portion 10 contains a printed circuit board (PCB) 14, two temperature sensors 16, 18, a piezo-electric sound generator 20, magnets 22 and 24, and LED lenses 26 and 28. The
30 main portion 8 of the main body 4 comprises electrical contacts 30, 32 connected to the PCB 14 by wires. The main portion 8 is designed to receive two AA batteries (not

shown) in a side-by-side relationship. The temperature sensors 16, 18 are separated by a distance of about 3cm in this embodiment.

The front of the box-like portion 10 has a cut away section 34, 36 moulded in each side thereof in the region of the piezo-electric sound generator 20. The cut away sections 34, 36 provide holes in the housing 2 to facilitate transmission of sound from the piezo-electric sound generator 20. The piezo-electric sound generator is attached to the interior surface of the housing to seal the edges of the cut away sections. The piezo-electric sound generator therefore closes the holes in the housing.

The box-like portion 10 may also comprise a drainage hole 38 to facilitate drainage of liquid from the housing.

The dividing plate 12 suitably provides a substantially water-tight seal between the box-like portion 10 and the main portion 8 of the main body 4 in order to prevent liquid entering the device through holes made by the cut away portion 34, 36 contacting the batteries (not shown). In addition, the dividing plate 12 separates the electronic apparatus from the battery compartment, such that when the cover 6 is removed to change the batteries, the electronic apparatus is not exposed.

The main body 4 provides a front wall 56, side walls 54 and a bottom wall 58 of the housing. The box-like portion 10 extends from the front wall 56 of the main body 4.

The cover 6 has a back wall 40, side walls 42, 44 and a top wall 46. Grooves 48 on the interior surfaces of the side walls 42, 44 co-operate with ridges 50 on the edges of the side walls 54 of the main body 4, to allow the cover 6 to slide into position on the main body 6.

Location of a detent 60 of the main body 4 in an opening 62 of the cover 6 maintains the cover 6 in a closed position on the main body 4.

A ridge 64 on the interior of the back wall 40 of the cover 6 are shaped to prevent the cover 6 is being slid onto the main body 4 in the wrong direction.

The cover 6 comprises a lip 66 extending from the top wall 46. The lip 66 is designed to provide a splash-proof shield between the upper surfaces of the cover 6 and main body 4 when the device is arranged for use.

The housing also comprises ridges 92 extending from the surface thereof to provide a shield about the temperature sensors 16, 18 from the external environment when the device is in use.

Two possible modes of operation of the device of figures 1-10 are illustrated in figures 11 and 12 and will be described below.

In use of the device of figs 1 to 10, the device is located on the exterior surface of a pressurised container of a volatile liquid. Preferably, the device is located towards the bottom end of the container so the device can be used to indicate when the container is almost empty.

The device is arranged with the front wall 56 facing the container. The magnets 22, 24 hold the device on the container (not shown) and the temperature sensors 16, 18 contact the surface of the container. The device should be arranged such that one sensor 16, 18 is located above the other. Preferably, sensor 18 is located above sensor 16. More preferably, sensor 18 is located substantially vertically above sensor 16 when the device is arranged for use.

The method of operation of figure 12 will be described below. At step 70, each temperature sensor 16, 18 take a measure of the temperature of the container at substantially the same time, producing temperature measurements T1 and T2. At step 72, temperature T1 is subtracted from temperature T2 and the temperature difference in a particular direction ΔT is ascertained. ΔT is then compared to a set of pre-set conditions.

If ΔT is less than X, where X is for example 1°C , 0.5°C or 0.05°C , then the temperature difference between T1 and T2 is considered to be insignificant and the device returns to step 70. Such a reading is assumed to indicate that the level of liquid is above the liquid level indicator or the container is not in use.

If ΔT greater than X, then it is considered that the liquid level is at or below the position of the liquid level indicator and a signal is sent to the piezo-electric sound generator 20, step 74, to sound an alarm, step 76.

The method of operation of figure 13 will be described below. At step 80, each temperature sensor 16, 18 takes a measure of the temperature of the container at substantially the same time $t=0$, producing temperature measurements T1 and T2. At step 82 each temperature sensor 16, 18 takes a measure of the temperature of the

container at substantially the same time, at a later time $t=1$, producing temperature measurements T3 and T4. At step 84, T3 and T1, and T4 and T2 are compared to determine whether or not the overall temperature of the container is falling with time. Where Y is 1°C , preferably 0.5°C , or more preferably 0.05°C . If the difference
 5 between T3 and T1 and the difference between T4 and T2 is less than Y then it is considered that the temperature of the container is not falling with time. This indicates that the container is not in use. If the difference between T3 and T1 or the difference between T4 and T2 is greater than Y then it is considered that the temperature of the container is falling with time. This indicates that the container is in use.

10 If the temperature of the container is falling with time, then the method will continue with the comparison steps 86. If the temperature of the container is not falling with time, then the method will return to step 80.

At step 86 T2 is compared to T1 and T4 is compared to T3. If ΔT is less than X, where X is for example 1°C , 0.5°C or 0.05°C , then the temperature difference
 15 between T1 and T2 is considered to be insignificant and the device returns to step 80. Such a reading is assumed to indicate that the level of liquid is above the liquid level indicator or the container is not switched on.

At step 86, if ΔT is greater than X then it is considered that the level of the liquid is at or below the position of the liquid level indicator and a signal is sent to the
 20 piezo-electric sound generator 20, step 88, to sound an alarm, step 90.

1/11

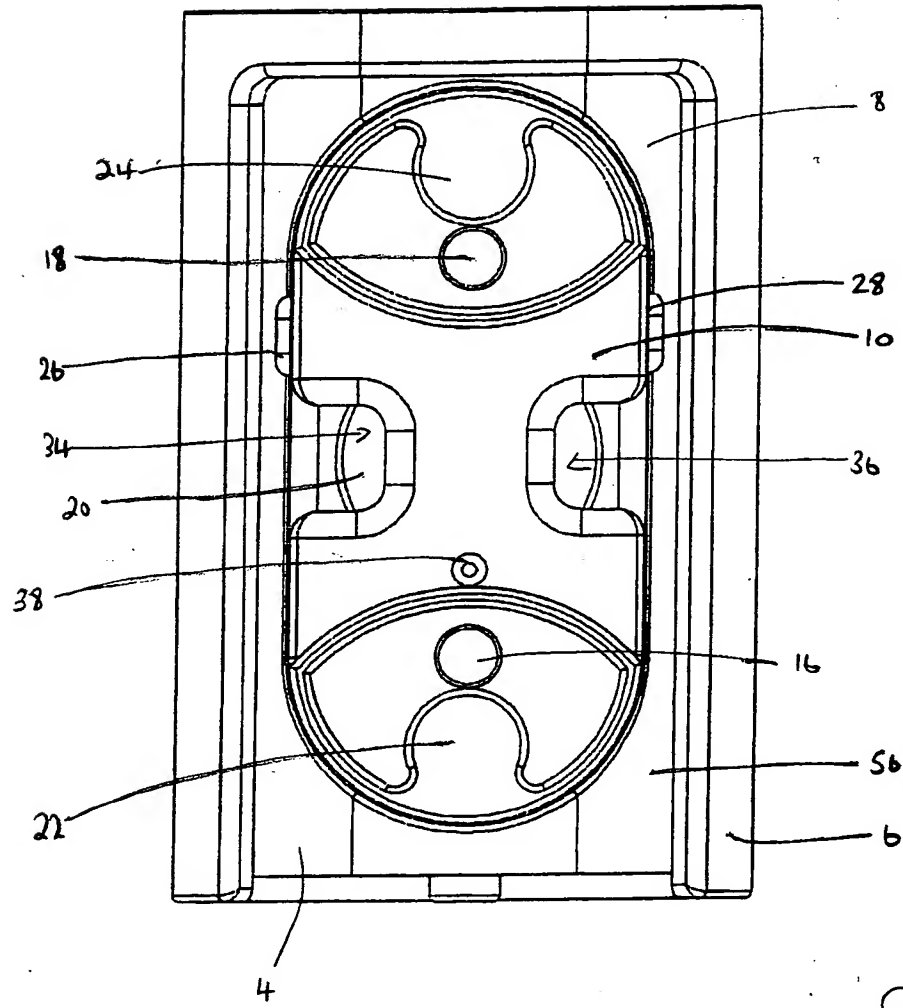


Fig 1

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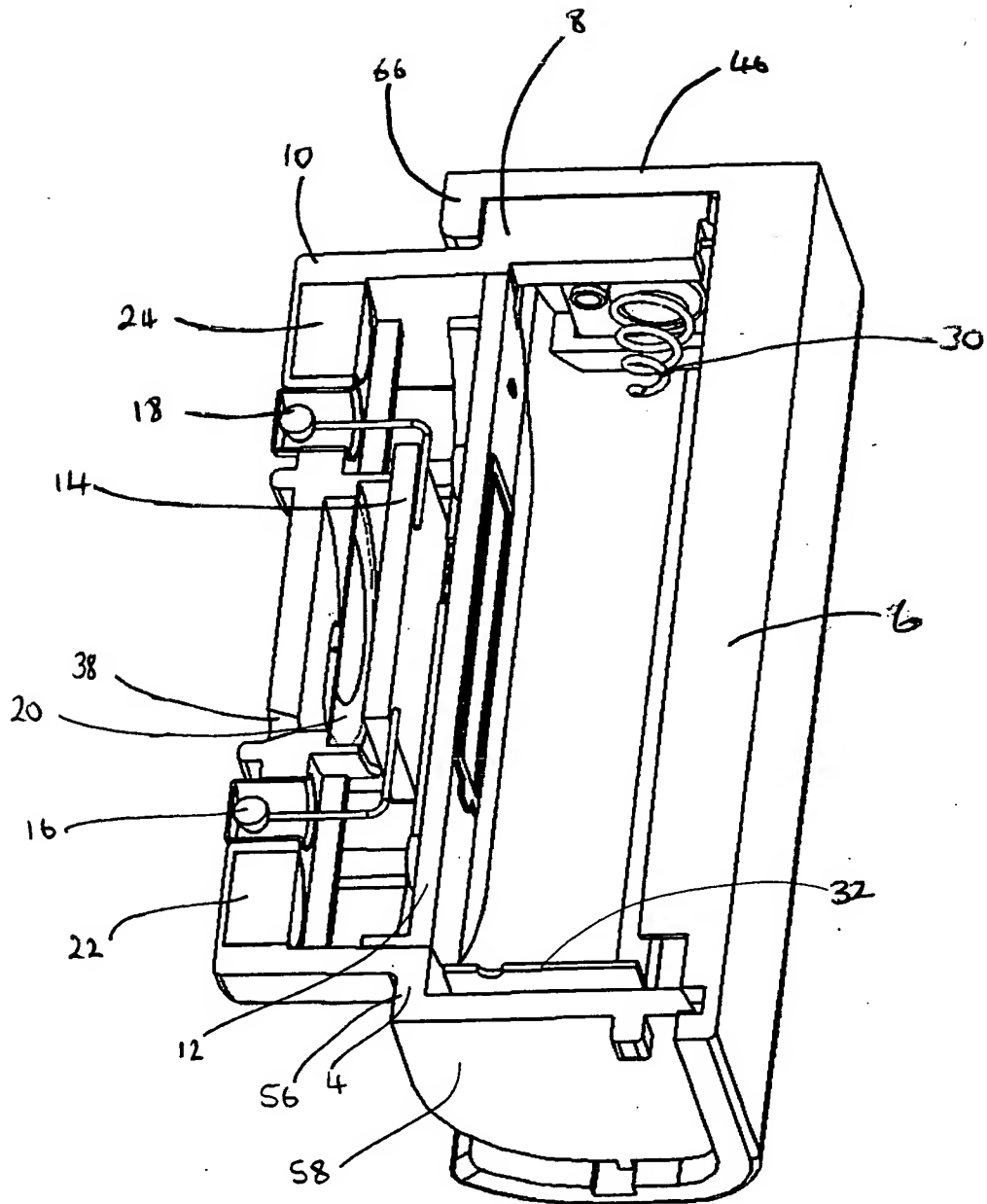


fig. 2

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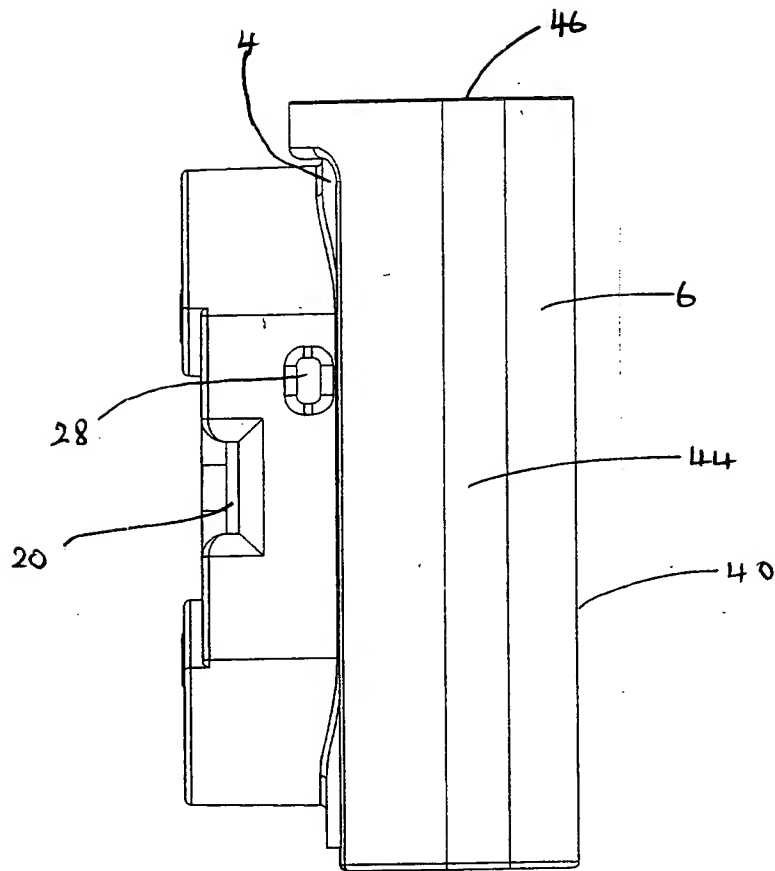


fig. 3

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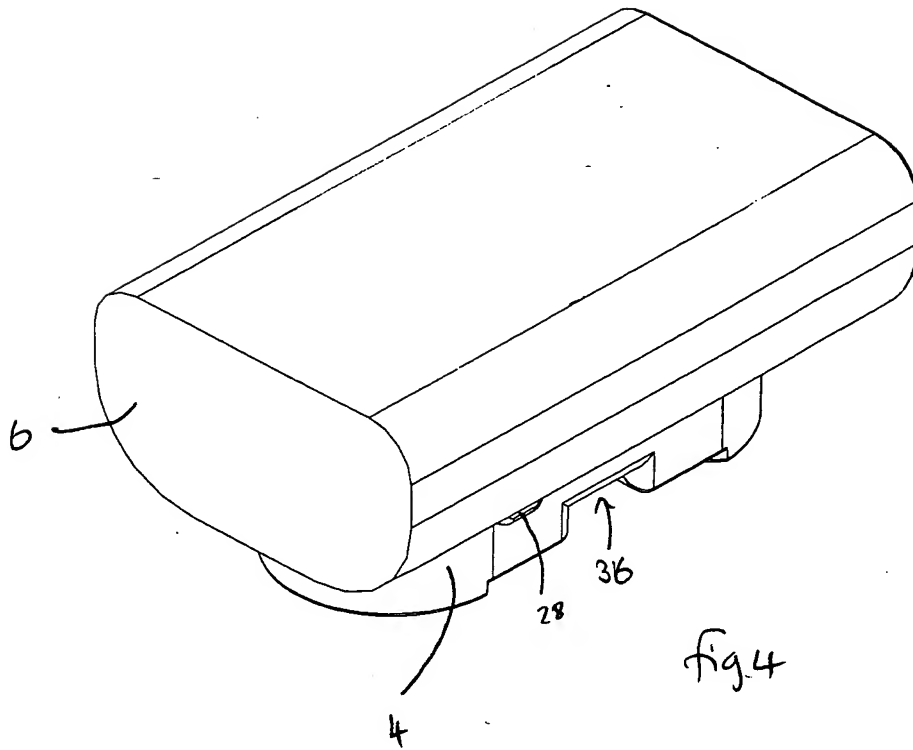


fig. 4

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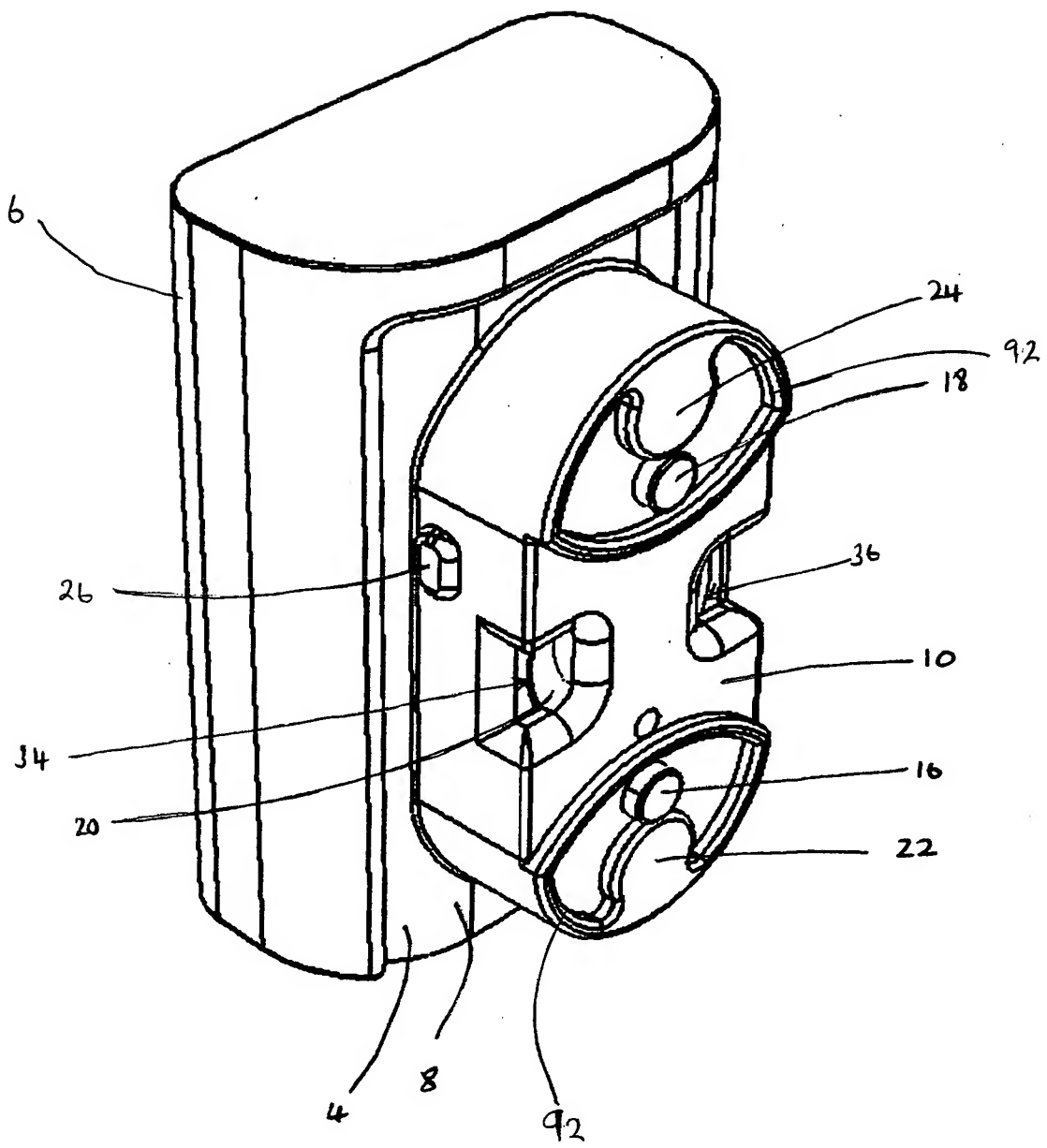


Figure 5

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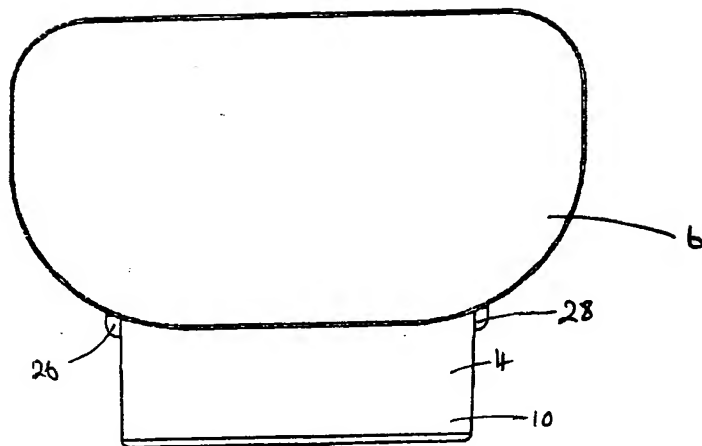


Figure 6

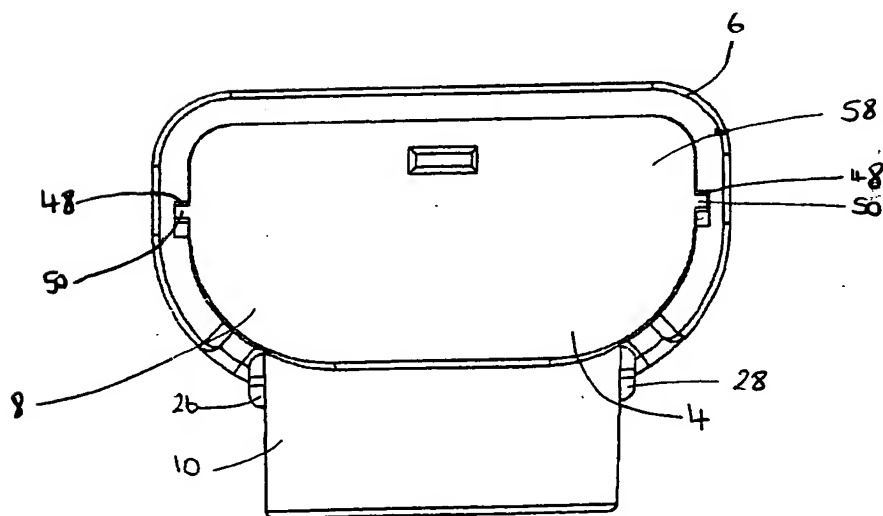
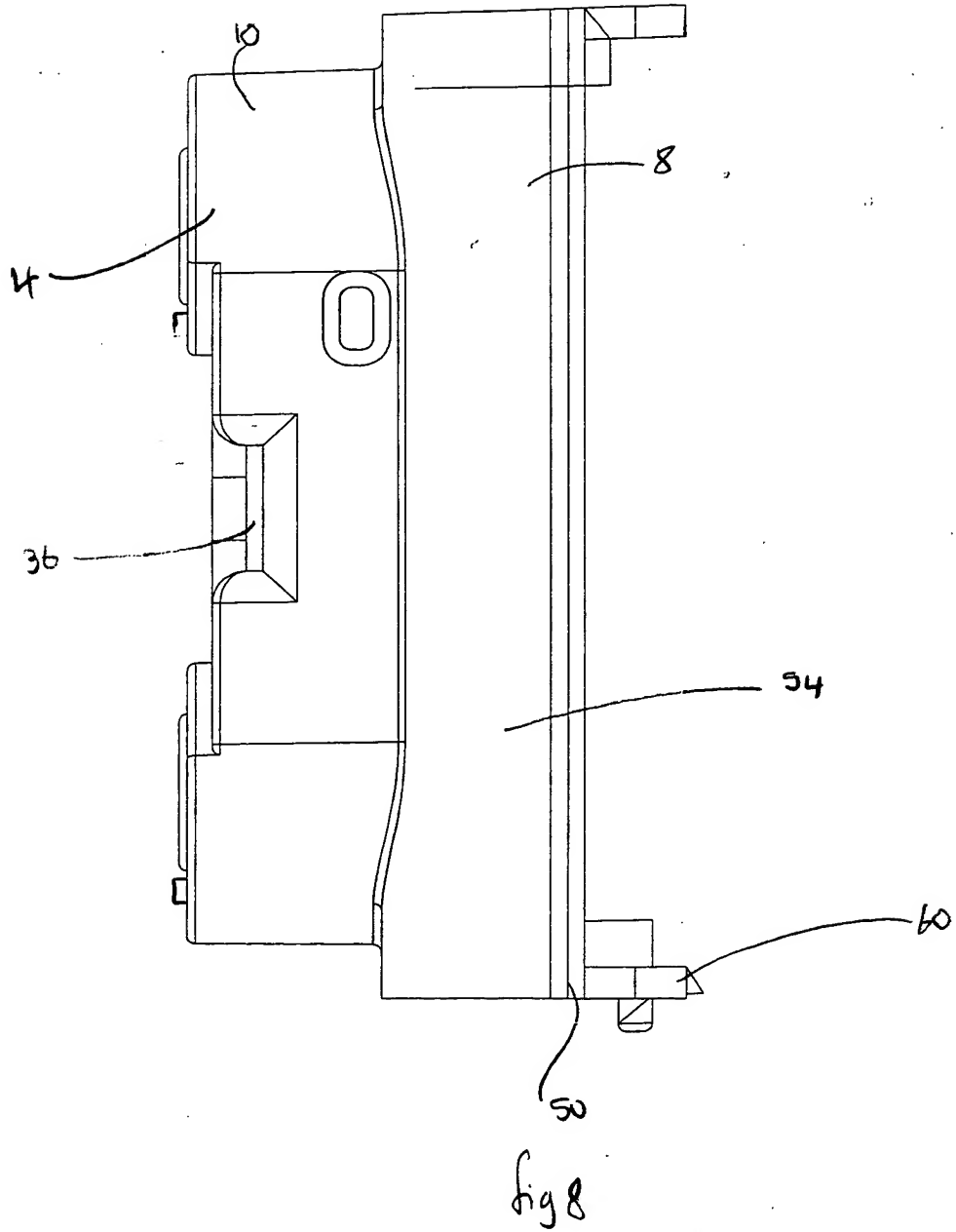


Figure 7

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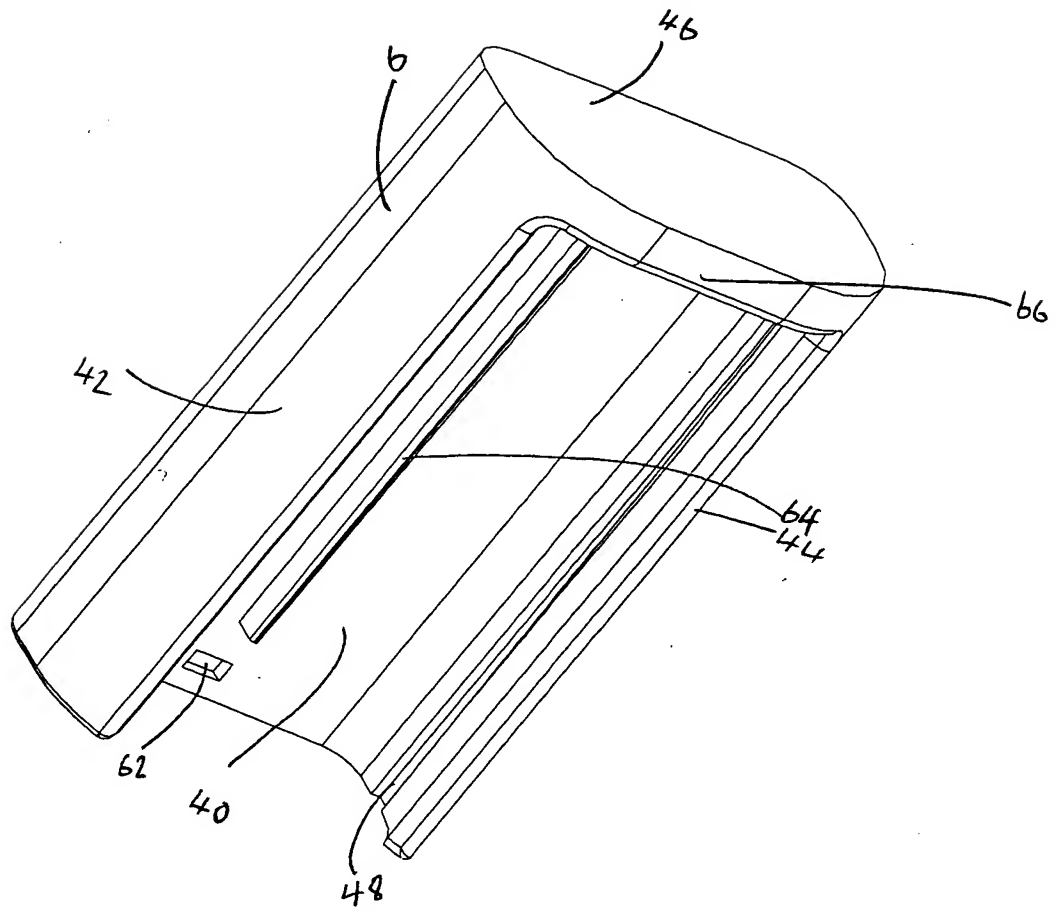


fig 9

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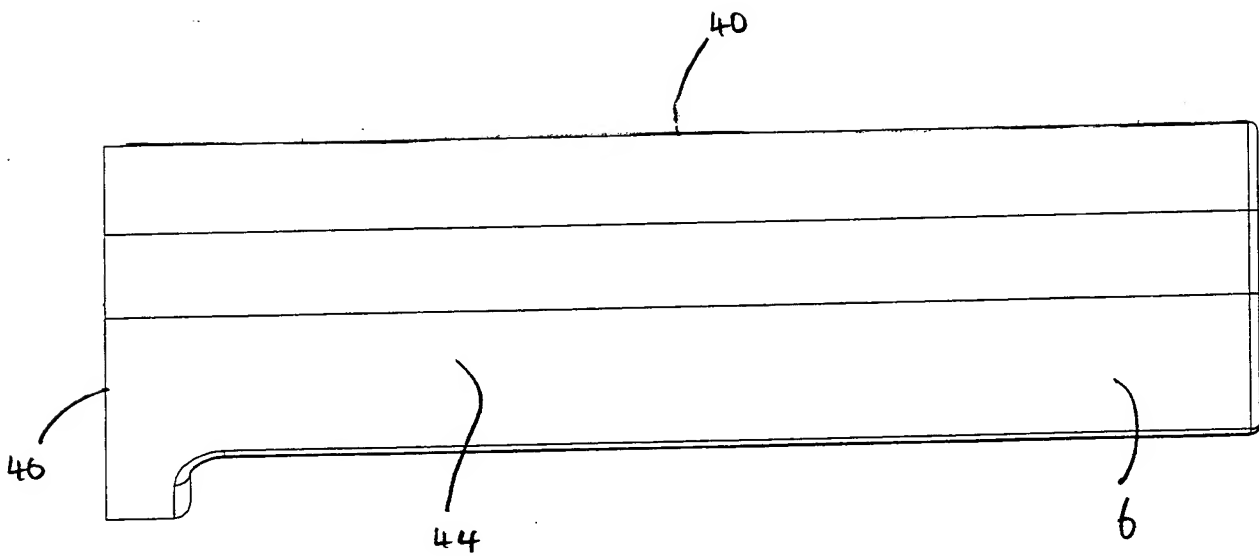


fig 11

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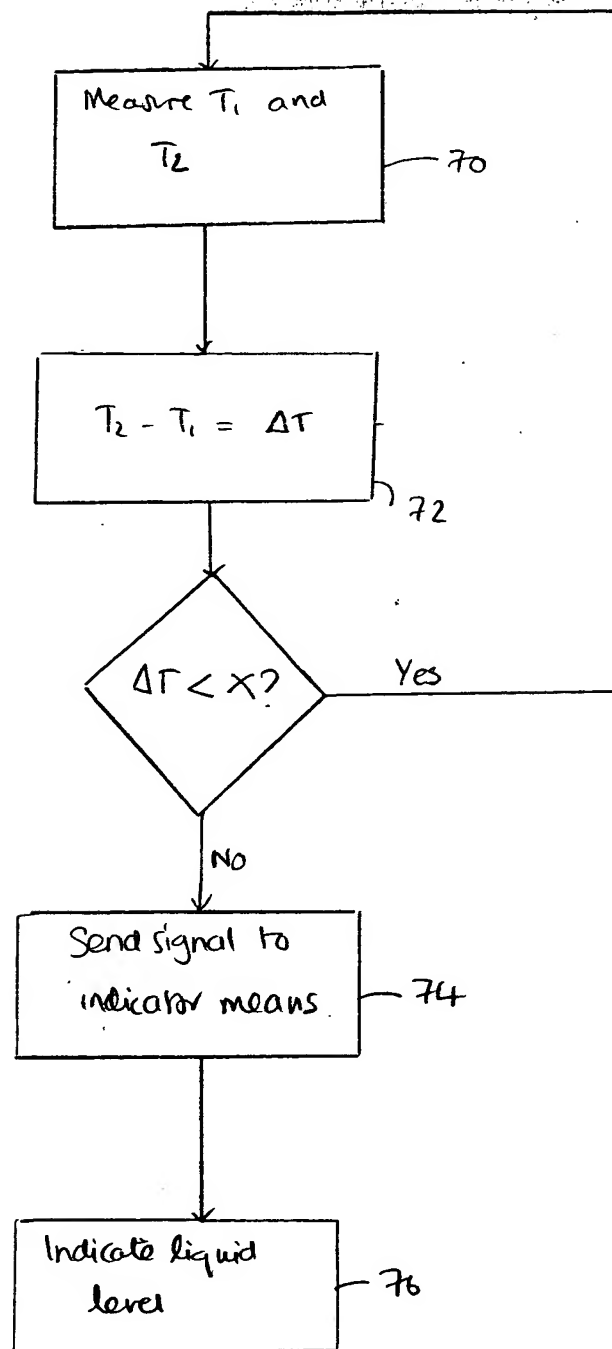


Fig. 11

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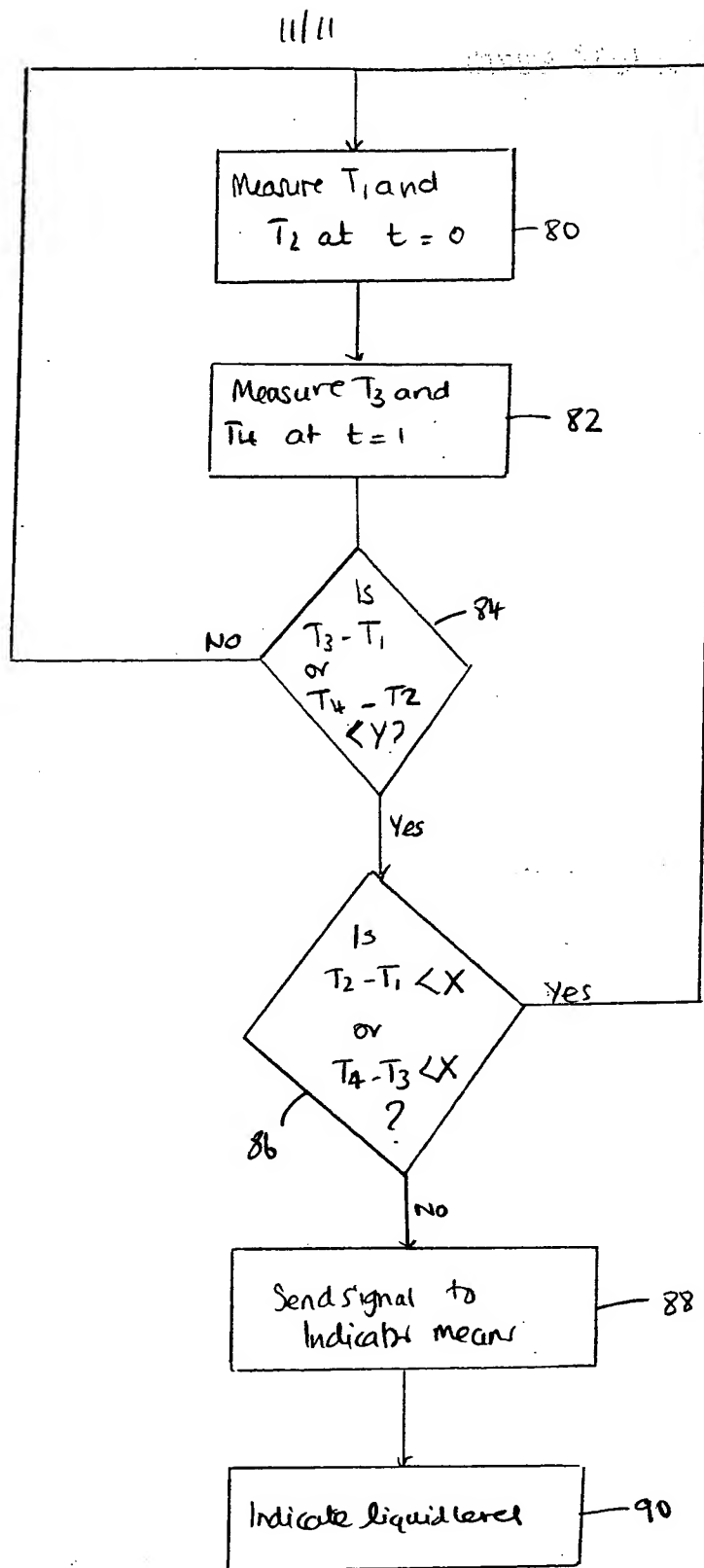


Fig 12

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